

**Senate Natural Resources and Water Committee**  
**June 18, 2013 Informational Hearing**  
**“Well Stimulation in the Oil and Gas Fields of California”**  
**Background paper**

**Overview**

Advances in oil and gas production technologies such as horizontal drilling have increased oil and gas reserves worldwide by making it technically and economically feasible to develop many new sources. Due to these advances, new estimates of the “unconventional” recoverable reserves in the Monterey Shale exceed 15 billion barrels<sup>i</sup> of oil – more than 60% of the shale oil reserves in the United States. One highly-visible and controversial well stimulation technology useful to developing these unconventional reserves is hydraulic fracturing – or “fracking.” While fracking has the highest profile, well operators are using another important well stimulation technology to recover oil and gas from the Monterey shale—acidization. Industry statements suggest that acidization may be more important to the development of the unconventional reserves in the Monterey Shale<sup>ii</sup> than fracking. For example, in a November 2010 interview with the Oil & Gas Financial Journal, former Venoco Inc. CEO (now Executive Chairman) Tim Marquez said, “We think our primary completion method will be big acid jobs” in the Monterey Shale<sup>iii</sup>. When asked about fracking in a May 2013 conference call with investors, the company’s current CEO, Ed O'Donnell said regulations would have little impact on the company because “fracking isn't something that we use so much to a great degree at all.”<sup>iv</sup> The goal of this informational hearing is to understand whether the legislative focus on fracking to the exclusion of other well stimulation techniques is warranted. The Department of Conservation will provide information on current regulatory practices, and stakeholders will provide their perspectives on the use, regulation and prospects of industry technologies.

**The Oil Industry in California**

California’s ranks fourth among the fifty states in the amount of oil produced.<sup>v</sup> While oil fields can be found throughout the state, most production is in Kern County (>70% of the total), and Los Angeles (12%) and Ventura Counties (4%) also produce significant quantities. California is also an important producer of natural gas – both associated and unassociated with oil production – and Kern County also dominates gas production. According to 2009 data provided by the Western States Petroleum Association (WSPA), approximately 100,000 people were directly employed in oil and gas production in California and the state received a combined \$5.8 billion in fuel excise, corporate and personal income taxes. A recent narrowly-focused economic study from the University of Southern California paid for by WSPA suggests that the new development of unconventional oil resources in the Monterey Shale will result in significant job and economic growth. The USC study, however, did not include the external costs and risks of recovering these reserves, and a follow-on report exploring environmental and other issues was promised.

**Oil resource development**

A “conventional” underground oil reservoir is located beneath and held in place by a layer of caprock. When a well is drilled through caprock into the conventional reservoir below, oil will readily flow to the wellbore (this is called primary production or recovery). By contrast, oil in an “unconventional” reservoir will not readily flow in economic quantities to the wellbore because the permeability of the

reservoir is very low. In order to enable production from unconventional reservoirs such as shale some form of well stimulation is required.

Well stimulation is generally defined as a treatment necessary to restore or enhance well productivity. The specific method chosen will depend upon the characteristics of the oil reservoir, geology and other factors. There are two general classes of well stimulation treatments – fracturing and matrix treatments. Fracturing treatments – including hydraulic fracturing – are at pressures that exceed the fracture pressure of the geologic formation containing the oil reservoir. The fractures in the formation created or enhanced by the treatment provide pathways for the oil to the wellbore. Hydraulic fracturing typically involves the pressurized injection of hundreds of thousands to millions of gallons of water mixed with chemical additives into the formation. “Proppant” (e.g. sand) is also typically injected to help keep the fractures open once the fracking fluid pressure is removed. However, proppant is not always used in fracturing treatments, such as those that use nitrogen gas as a fluid or in some acid fracturing treatments<sup>vi</sup>.

Early matrix stimulation treatments pre-date the development of hydraulic fracturing and some forms have been in common use for multiple decades. Traditionally, treatments are designed to address damage near the wellbore due to drilling. In contrast to fracking, matrix stimulation treatments are performed at applied fluid pressures below the fracture pressure of the geologic formation where the reservoir is located. Acid matrix treatments dissolve some of the minerals in the formation to create new or enhance existing channels between the wellbore and the formation thus increasing reservoir permeability and improving oil production. Acid matrix treatments typically involve a multi-stage process where there is a “pre-flush” of fluids, followed by the main treatment and a final “overflush”. Two strong acids – hydrochloric (HCl) and hydrofluoric (HF) – are routinely used in acid matrix stimulation. The relative amounts of each depend upon geology, and HF has the advantage that it can dissolve silicates. The strong acid concentration in the main treating fluid can be up to 30%, depending upon the purpose of the treatment, and HF concentrations tend to be low (a few percent). In addition to the primary acid components, other chemicals used in the treatment include solvents, surfactants, corrosion inhibitors, oxidizers and scale removers. The treatment may also be applied in various forms (e.g. as foams, gels or emulsions). The volume injected is typically reasonably low (5 gallons per well foot) but there are reports that substantially increased volumes (up to 250 gallons per foot)<sup>vii</sup> may be used in wells producing the unconventional Monterey Shale resource. Given these high volumes reported, these treatments may be designed to affect far more of the formation than traditionally targeted.

### **Development of the unconventional Monterey Shale oil resource**

Recent mineral rights leasing activity in locations that include the unconventional Monterey Shale oil resource indicate substantial industry interest in developing oil production.<sup>viii</sup> While the use of hydraulic fracturing to develop oil production has received considerable public, legislative and regulatory attention, there is evidence that hydraulic fracturing may not be the primary stimulation technique used. For example:

- Recent industry conferences focused on unconventional resources have had sessions devoted to acid stimulation techniques.<sup>ix</sup>

- The oil industry itself has reported that “large scale acid treatments” are integral to producing the unconventional part of the Monterey Shale formation.<sup>x</sup>
- In addition to the then-CEO’s comment noted above, Venoco, in a 2010 investor presentation, indicated that fracking and acidizing had been used in the Montalvo field (Ventura County).<sup>xi</sup> Reuters recently reported that Venoco estimated that “eight of every 10 Monterey wells could be completed with acid jobs alone.”<sup>xii</sup>
- Occidental Petroleum’s president of oil and gas operations in the Americas stated in a 2011 earnings call with investors with reference to California shale wells that “it’s mainly acid-jobs driven and we’re just treating these wells in larger intervals with more acid.”<sup>xiii</sup>
- An article in the September 2012 edition of the Oil and Gas Financial Journal reports “Best practices in the Monterey shale do not call for multi-stage fracs, which are common in other shale plays. Instead, operators like Occidental Petroleum, the largest lease-holder in the Monterey shale, prefer large-volume hydrofluoric acid jobs. Oxy says that the multi-stage fracs don’t work in the Monterey shale and the company has concluded that acid jobs yield better results overall.”<sup>xiv</sup>

In light of these reports, it is important to try to understand how all well stimulation techniques – not just hydraulic fracturing – are regulated in California.

### **Current regulatory practices – keeping pace with technology?**

The Supervisor of the Division of Oil, Gas and Geothermal Resources (DOGGR) in the Department of Conservation has extensive and broad authority to regulate activities associated with the production and removal of hydrocarbons (e.g. oil and gas) from the ground (Public Resources Code §3106). This includes the subsurface injection of water and other fluids. The supervisor’s authority is granted in order to prevent damage to life, health, property, natural resources, and to underground and surface water suitable for irrigation or domestic purposes.

In response to legislative and public pressure and after repeatedly acknowledging that it had no information on fracking despite its widespread use, DOGGR is in the process of developing fracking-specific regulations. The “discussion draft” of the proposed regulations was released in December 2012 and DOGGR is in the process of evaluating the comments received before issuing a revised proposal. DOGGR’s “discussion draft” clearly distinguishes fracking as a separate practice from those covered by its existing injection well regulatory program for enhanced oil recovery, although fracking and other well stimulation techniques may be used on wells that are part of injection well projects.<sup>xvxi</sup>

### **May 2013 letter to the Department of Conservation**

On May 30, 2013, Senator Pavley and Assemblymember Chesbro – the respective chairs of the Senate Natural Resources and Water and Assembly Natural Resources Committees – sent a letter to the Department of Conservation asking for information on how DOGGR currently regulates well stimulation techniques in California, with a focus on acidization. The Supervisor’s authority, as cited above, clearly extends to the regulation of well stimulation techniques and it is not known what information is systematically collected and reviewed by DOGGR or made publicly available regarding acidization and other well stimulation techniques. Although specific details are unclear, industry

statements and reports suggest that advances in acidization stimulation treatment technologies go well beyond traditional practices of small injections to clean-up in and around the wellbore.

### **This hearing<sup>xvii</sup>**

The Department of Conservation has been asked to respond to the letter at the hearing.

Environmental and public concerns about acidization are similar to those related to fracking where technological advances and changes in use far outpaced existing regulatory practices. Wide-spread large scale acidization treatments may present risks to public and environmental health and safety that have not been fully recognized, evaluated or regulated.

Venoco, Occidental Petroleum, Chevron and Halliburton were all invited to the hearing to provide information on their well stimulation practices in California, as well as their use and re-use of recycled water in oil operations. All declined attending the hearing in person and Halliburton provided written testimony, which included information on Halliburton's position on trade secret fracking chemicals. WSPA and the California Independent Petroleum Association will instead represent the oil industry.

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<sup>i</sup> US Energy Information Administration estimate <http://www.eia.gov/analysis/studies/usshalegas/pdf/usshaleplays.pdf>

<sup>ii</sup> The Monterey Shale is currently the source of significant conventional oil and gas production in California (production started in 1895). The more recent focus of industry and media attention is on developing its "unconventional" resources.

<sup>iii</sup> <http://www.ogfi.com/articles/print/volume-7/issue-11/cover-story/venoco-has-comfort-zone-in-california-plans.html>

<sup>iv</sup> <http://seekingalpha.com/article/1433931-venoco-management-discusses-q1-2013-results-earnings-call-transcript?part=single>

<sup>v</sup> Roughly 200 million barrels of oil produced annually from 2010 - 2012

<sup>vi</sup> See, for example, Wozniak et al. (2010). Completion Optimization in the Lower Huron Shale in Kentucky. SPE 138254, presented at the Society of Petroleum Engineers' Eastern Regional Meeting, Morgantown, WV, October 12 – 14, 2010.

<sup>vii</sup> Shaari et al. (2011). Is there a "Silver Bullet Technique" for stimulating California's Monterey Shale? SPE 144526, presented at the Society of Petroleum Engineers' Western North American Regional Meeting, Anchorage, AK, May 7 – 11, 2011.

<sup>viii</sup> See, for example, the April 20, 2013 story in the Ventura County Star "New leases reveal an oil land rush in Ventura County" and the recent mineral rights leasing activity (now suspended) by the Bureau of Land Management

<sup>ix</sup> Among many – the Society of Petroleum Engineers' Western Regional Meeting, March 21 – 23, 2012 in Bakersfield, California and the Tight Oil Reservoirs Conference, May 29 – 30, 2013 in Bakersfield

<sup>x</sup> See presentation for analysts by Occidental Petroleum's VP of California Operations (Todd Stevens) from May 19, 2010 available at <http://www.gridpetroleum.com/wp-content/uploads/2011/04/Stevens-Oxy-2010-Analyst-Meeting.pdf>

<sup>xi</sup> Venoco, Inc. Monterey Shale Focused Analyst Day presentation – May 26, 2010, New York

<sup>xii</sup> <http://www.reuters.com/article/2013/05/28/us-california-oil-insight-idUSBRE94R0CO20130528>

<sup>xiii</sup> <http://seekingalpha.com/article/266377-occidental-petroleum-management-discusses-q1-2011-results-earnings-call-transcript?part=single>

<sup>xiv</sup> <http://www.ogfi.com/articles/print/volume-9/issue-9/features/diverse-unconventional-resource-plays.html>

<sup>xv</sup> See, for example, McClatchie et al., (2004). Injection well stimulation. Putting away more for less in California waterfloods. SPE 90815, presented at the Society for Petroleum Engineers' annual Technical conference and exhibition, Houston, TX, September 26 – 29, 2004.

<sup>xvi</sup> Injection well projects to enhance oil and gas production (i.e. Enhanced Oil Recovery (EOR) projects) are distinct from well stimulation injections in the sense that they tend to be continuous injections directly related to driving production as opposed to intermittent wellbore or formation treatments meant to remove barriers to production. When primary production begins to falter as the reservoir pressure falls, a fluid (water and/or gas) is injected into the reservoir to boost the reservoir pressure and help drive the oil to the wellbore. Thermal or chemical methods may also be used to alter the properties of the oil to enhance recovery. Waterflooding, steamflooding, cyclic steam injection are all examples of injection well projects. These are currently regulated under 14 CCR §§ 1724.6 – 1724.10.

<sup>xvii</sup> In addition to the cited material, the Schlumberger oil field glossary, Reservoir Stimulation (3<sup>rd</sup> ed) by Economides and Nolte, Production Enhancement with Acid Stimulation by Kalfayan, helpful discussions with Professor Donald Turcotte (UC Davis) and material available on-line by Dr. George E. King and Dr. A.K. Pandey were all consulted.